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Review Article

Progress of colorectal cancer screening in United States: Past achievements and future challenges☆,☆☆

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ABSTRACT

The United States has seen progress with colorectal cancer with both falling incidence and mortality rates. Factoring into this decline, the significance of early detection and removal of precancerous lesions through screening must be underscored. With the advancement of screening modalities, attention has been directed towards optimizing the quality of screening and detecting adenomas. Colorectal cancer screening has been a major agenda item for national gastroenterology societies, culminating in a major victory with passage of the Balanced Budget Act that allowed for Medicare coverage of colorectal cancer screening. Colonoscopy as the primary screening modality was solidified in the 1990s after landmark studies demonstrated its superiority over modalities for detecting precancerous polyps. Despite progress, colorectal cancer screening disparities between race and gender continue to exist. Legislative efforts are on-going and include the SCREEN Act and Dent Act that aim to further improve access to screening. The National Colorectal Cancer Roundtable has launched colorectal cancer screening initiatives targeting at risk populations. Today, the current goal of these initiatives is to reach colorectal screening rate of 80% of eligible patients by 2018. With these initiatives, efforts to narrow the gaps in screening disparities and lower overall mortality have been prioritized and continued by the medical community. This review article details colorectal cancer screening progress to date and highlights major studies and initiatives that have solidified its success in the United States.

1. Introduction

Over the past four decades, the United States has seen progress with colorectal cancer (CRC) with both falling incidence and mortality rates. While many factors may contribute to this decline (decreased smoking, dietary changes, use of aspirin, improvements in medical and surgical treatment), the significance of early detection and removal of pre-cancerous lesions through screening must be underscored. CRC screening is defined as routine examinations for detection of pre-cancerous or cancerous lesions within the large colon and rectum in asymptomatic patients (American Cancer Society, 2017a). CRC screening has been a major agenda item for major gastroenterology societies, which culminated in a major victory in 1997 with passage of the Balanced Budget Act for the first time providing Medicare coverage for CRC screening. Now, on the 20th anniversary of this achievement, we are looking towards the goal of reaching a CRC screening rate of 80% of eligible patients by 2018. This article aims to commemorate the 20th anniversary of screening coverage by Medicare and details the advancement of CRC screening modalities, legislation, and initiatives since screening inception (Figs. 1 and 2).

2. Scope of the colorectal cancer burden from 1975 to today

In 1975, overall CRC incidence rates were 68.4/100,000 for men and 53.7/100,000 for women with death rates of 33.2/100,000 and 25.2/100,000 for men and women, respectively. (American Cancer Society, 2017b). From 1975 to 1985 CRC incidence peaked in men to 79.2/100,000 and 57.3/100,000 in women. Over this decade, death rates remained steady for men and decreased for women. Despite rising incidence, the stable death rates suggest that therapies were improving

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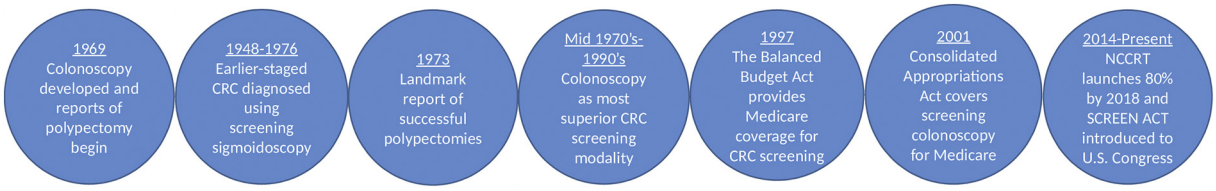

Fig. 1. Progress of endoscopy development and coverage from 1969 to Present.
Colonoscopy is developed in 1969, which is followed shortly by initial reports of polypectomies. Wolff and Shinya (1973) detail polypectomies without mortality and minimal morbidity. From the mid-1970s–1990s, colonoscopy is established as a superior CRC screening modality. In 1997 and 2001, The Balanced Budget Act and Consolidated Appropriations Act are passed to provide access to screening colonoscopy. In 2014, the NCCRT launches the 80% by 2018 campaign. In 2015, the SCREEN Act is introduced to the United States Congress.

Fig. 2. Progress of stool-based CRC screening modalities.
CRC detection using gFOBT is reported in 1901. Greegor (1967) demonstrates CRC detection in asymptomatic patients using gFOBT. FIT is introduced in 1978. In 1993, CRC reduction is demonstrated using gFOBT screening. USPSTF endorses gFOBT and FIT in 1996.

and CRC was identified at earlier stages (American Cancer Society, 2017b).

Today, the American Cancer Society (ACS) most recently estimates that 140,250 new cases of CRC will occur in 2018 (Siegel et al., 2018). Deaths from CRC in 2018 are estimated to reach 50,630, making CRC the third most common cause cancer-related deaths for men and women, excluding skin (Siegel et al., 2018). The median age of diagnosis for men is currently 68 and in women 72 (Howlader et al., 2015). CRC is estimated to follow breast, lung, and prostate as the fourth most common cancer to be diagnosed in 2018, and will be second only to lung as the cause of cancer-related deaths in men and women combined (Howlader et al., 2015; Siegel et al., 2018). Overall, the 2018 CRC 5-year survival is 65% (Siegel et al., 2018). The 5-year survival for localized disease is 90%, however this rate continues to drop precipitously to 14% for metastatic disease (Siegel et al., 2018).

Data continue to show racial disparities in CRC in incidence and mortality today. The lowest incidence rates are seen in Asian and Pacific Islanders, (32.2/100,000) (American Cancer Society, 2017b). However, a study investigating CRC incidence in sub-groups of Asian and Pacific Islanders in California demonstrated differences by country of origin of foreign-born patients (Ladabaum et al., 2014). Foreign-born South Asians from countries such as Vietnam, India, Pakistan, Sri Lanka, and Bangladesh had the lowest incidence rate (22.0/100,000), while the foreign-born Japanese sub-group had the highest incidence (79.2/100,000). When compared to white Californians, incidence was only higher in Japanese and US-born Chinese. The Incidence rate of foreign-born Japanese patients was significantly higher than US-born Japanese, 121.9/100,000 and 62.3/100,000, respectively (Ladabaum et al., 2014). Asian and Pacific Islander incidence rates are followed closely by Hispanic incidence rates (35.5/100,000) (American Cancer Society, 2017b). Differences have been demonstrated in foreign-born Mexican and foreign born Puerto Rican patients compared to their US-born counterparts (Jackson et al., 2016; Monroe et al., 2003; Ho et al., 2009). Incidence rates of foreign-born Mexicans are lower compared to following generations that are born in the United States (Monroe et al., 2003). Similarly, US-born Puerto Rican incidence rates approach that of white patients compared to native Puerto Rican incidence rates (Ho et al., 2009).

African-Americans continue to suffer the poorest outcomes from CRC. The American Cancer Society most recently reports that 17,240 African-American will receive a diagnosis of CRC yearly (American Cancer Society, 2017b; American Cancer Society, 2016). Prior to 1989, the incidence of CRC was higher in white men and women compared to African-American men and women. After 1989, CRC incidence rates have decreased more rapidly in white men and woman compared to African-American men and women (Williams et al., 2016). Most recent comparisons of incidence rates for African Americans and white Americans are 60.3/100,000 versus 47.4/100,000 for men and 44.1/100,000 versus 36.2/100,000 for women (Ladabaum et al., 2014; Karami et al., 2007). Of these new diagnoses, African-Americans continue to have CRC diagnosed at $\leq$50 years-old compared to white Americans (American Cancer Society, 2016; Karami et al., 2007; Abdelsattar et al., 2016; Agrawal et al., 2005; Henschke et al., 1973; Surveillance, Epidemiology, and End Results (SEER) Program (www.seer.cancer.gov), 1969-2012).

The ACS also reports 7030 African-Americans will die from CRC yearly (American Cancer Society, 2017b; American Cancer Society, 2016). When comparing most recent CRC death rates, African-American men have a 52% higher death rate compared to white men (American Cancer Society, 2016; Surveillance, Epidemiology, and End Results (SEER) Program (www.seer.cancer.gov), 1995-2012). African-American women have a 41% higher increased CRC death rate compared to white women. These death rate disparities are present in past years. African-American 5-year survival rate was 45% in 1975–1977 compared to 50% for white Americans (Howlader et al., 2015; American Cancer Society, 2016). Over 2005–2011, 5-year survival rates for African-Americans improved to 59%, yet were still lower than the 67% for white Americans (Howlader et al., 2015; American Cancer Society, 2016).

A component of this disparity includes differences in screening rates (Jackson et al., 2016). Screening rates for African-Americans have been shown to be less than whites regardless of screening modality choice (Jackson et al., 2016; American Cancer Society, 2016; May et al., 2014). A study by National Centers for Health Statistics has shown improvement in the disparities in CRC screening for African-American. Statistics obtained from 2000 to 2013 has shown African-American CRC screening increasing from 32% in 2000 to 59% in 2013 (American Cancer Society, 2016; National Center for Health Statistics, n.d.). The 2013 screening rate was comparable to white American rates of 61% (American Cancer Society, 2016; National Center for Health Statistics, n.d.). Most recent data from the ACS reports African-American CRC screening rates of 61% compared to white screening rates of 65%

(American Cancer Society, 2017b). The combination of increased screening rates, the American College of Gastroenterology (ACG) recommendation to begin screening at age 45, and national campaigns aim to narrow outcome disparities between African-American and white American CRC patients (Rex et al., 2009; National Colorectal Cancer Roundtable, n.d.).

Of note, the ACS has released new guidelines for CRC screening in 2018 that include a recommendation to start screening in all average-risk patients at 45 years-old now instead of just average-risk African-Americans (Wolf et al., 2018). This 2018 update from the ACS was made after observational evidence by the National Cancer Institute Surveillance Epidemiology and End Results Program demonstrated a 51% increase in CRC incidence in patients aged 20–49 years-old since 1994 (Surveillance Epidemiology and End Results (SEER) Program, 2017). Reasons for why this increase has occurred in patients 20–49 years-old is not well understood at this time and is being further investigated (Wolf et al., 2018). To date, no adequately powered randomized trials have been conducted to measure the benefits of starting average-risk screening in the United States. Currently, American gastroenterology societies are reviewing this observational data to determine whether or not to also recommend changing the starting age for screening average-risk patients.

3. Development and validation of colorectal cancer screening modalities

3.1. Fecal guaiac, immunochemical testing, and fecal DNA

The value of guaiac fecal occult blood test (gFOBT) for detecting CRC was demonstrated by Boas in 1901 (Simon, 1985; Irons and Kirsner, 1965). In 1967, gFOBT as a screening method grew after Greegor reported its use in the detection of asymptomatic tumors (Simon, 1985; Greegor, 1967, 1972). Subsequent larger studies supported using gFOBT for CRC detection and supported screening for asymptomatic CRC as standard practice (Hastings, 1974; Winchester et al., 1980). A study by Mandel et al. (1993) was the first randomized control trial to evaluate the effect of CRC screening and used gFOBT as its intervention. The study screened 46,551 asymptomatic patients and demonstrated annual gFOBT reduced CRC mortality by 33% (Mandel et al., 1993).

In 1978, fecal immunochemical testing (FIT) was introduced by Barrows and Songster as an alternative to gFOBT (Simon, 1985; Barrows et al., 1978; Songster et al., 1980). FIT has demonstrated higher sensitivity for occult bleeding compared to gFOBT by detecting human hemoglobin in stool (van Rossum et al., 2008; Dancourt et al., 2008). Due to increased popularity and demonstrated value, FIT and gFOBT were introduced into United States Preventive Services Task Force (USPSTF) CRC screening recommendations in 1996, but the United States Multi-SocietyTask Force on Colorectal Cancer (MSTF) had endorsed their use years previously (U.S. Preventive Services Task Force, 1996; Winawer et al., 1991). Current USPSTF colorectal screening guidelines continue to recommend FIT or gFOBT as an alternative to colonoscopy, with FIT continuing to be preferred over gFOBT because of higher sensitivity and positive predictive value for cancer as well as higher patient compliance (Bibbins-Domingo et al., 2016; Oort et al., 2009).

The focus on less invasive testing and more focus on specific CRC genetics has led to the development of multi-target stool DNA testing for asymptomatic CRC screening (Ahlquist et al., 2012). The development of FIT-Fecal DNA test (Cologuard; Exact Sciences; Boston, Mass), evaluating for mutations such as aberrantly methylated BMP3/NDRG4 promoters, KRAS, and β–actin in the stool, has shown promise, but cost analyses and decreased specificity compared to FIT and therefore is currently recommended as a tier-two screening exam. (Ahlquist et al., 2012; Imperiale et al., 2014; Rex et al., 2017).

3.2. Barium enema and CT colonography

Barium enema as a means for colonic imaging was first described by Schule (1904). This first single-contrast enema relied on bismuth subnitrate suspensions and was performed without fluoroscopy (Schule, 1904; Levine and Yee, 2014). In 1911, imaging of luminal narrowings was obtained by coupling fluoroscopy with single-contrast barium enema (SCBE) (Levine and Yee, 2014; Haenisch, 1911). With the addition of fluoroscopy to barium enema, Carman described tumor identification in 1923 (Levine and Yee, 2014; Carman and Fineman, 1923). The first double-contrast barium enema (DCBE) was also introduced in 1923, and its use for CRC detection began in 1930 (Levine and Yee, 2014; Fischer, 1923). Barium enema popularity grew throughout the mid-20th century as advancements in barium suspensions, colon cleansing, and equipment were developed (Levine and Yee, 2014; Fork et al., 1982). Studies comparing SCBE and DCBE found that DCBE identified more polyps, both greater and < 1 cm (Ott et al., 1986, 1989). In 2000, a landmark prospective, blinded study by Winawer et al. compared colonoscopy and double-contrast barium enema for CRC screening. Patients recruited in the study underwent a DCBE followed by colonoscopy 2 weeks later. The number and types of polyps identified were compared between modalities. Both highly-skilled endoscopists and radiologists participated in the study and were blinded. Patients were given identical preps prior to each modality. Of the 862 patients completing the protocol, results demonstrated a positive exam 19% more frequently with colonoscopy compared to DCBE. Furthermore, of the 791 polyps detected by colonoscopy, only 160 polyps (20%) were initially detected by DCBE, and of those 791 polyps detected, 371 (47%) were histologically classified as adenomas (Winawer et al., 2000). Despite advancements in barium enema, cost-effectiveness remained an issue due to high labor intensity and time consumption (Levine and Yee, 2014; Levine et al., 2002). Due to these burdens and evidence of inferiority to colonoscopy for CRC screening, barium enema was ultimately dropped from 2008 USPSTF CRC screening guidelines (Levine and Yee, 2014; U.S. Preventive Services Task Force, 2008).

In 1994, Vining and colleagues introduced Computed Tomography Colonography (CTC) as a screening tool for pre-cancerous polyps and CRC (Vining et al., 1994a, 1994b). At that time, CTC was thought to be a novel technique that combines helical computed tomography of a prepped colon with 3-dimensional imaging software to generate the mucosal surface (Vining et al., 1994a; Hara et al., 1996). CTC was demonstrated to be more effective than barium enema at diagnosing CRC and large polyps, resulting in CTC essentially replacing barium enema as a CRC screening option (Tolan et al., 2007; Halligan et al., 2013). CRC screening studies in asymptomatic patients comparing CTC to colonoscopy are abundant and have continued to demonstrate that CTC is as efficacious as colonoscopy at detecting polyps > 10 mm, but inferior to colonoscopy at detecting smaller polyps (Macari et al., 2002; Pickhardt et al., 2003). Thus, CTC has remained an alternative to colonoscopy for CRC screening, but has generally been a secondary option (Rex et al., 2017).

3.3. Endoscopy

Direct visualization modalities started with prototypes called “gastrocameras” that were introduced by Olympus® in 1950. In 1958, Matsunaga and Niwa demonstrated the utility of these primitive cameras by photographing gastric and sigmoid mucosa (Cotton et al., 2008). These cameras were often limited by poor lighting and mobility, and therefore their use was limited. Also during the 1950s, Basil Hirschowitz, Larry Curtis, and C. Wilbur Peters developed an endoscope prototype that used flexible fiberoptic bundles to allow for improved visualization of hollow organs such as the esophagus, stomach, and colon (Hirschowitz, 1979). In 1957, Hirschowitz famously demonstrated the utility of his “fiberscope” prototype by visualizing his own esophagus (Hirschowitz, 1979; Campbell et al., 2016). With increased

mobility and lighting, fiberoptic endoscopy enhanced direct assessment of mucosal lesions (Campbell et al., 2016).

Flexible sigmoidoscopy prototypes using fiberoptic bundles were first described by Overholt in 1961 as a means to eliminate undesirable features associated with rigid sigmoidoscopy and provide further visualization of the colon (Cotton et al., 2008; Overholt, 1969; Winnan et al., 1980). First commercial use of flexible sigmoidoscopy date shortly thereafter in 1965 and remained a screening option with fecal occult blood testing in asymptomatic patients for much of the 1980s and 1990s in the United States (Cotton et al., 2008; Overholt, 1969). Fiberoptic colonoscopy was developed and introduced by William Wolff and Hiromi Shinya with Olympus® in 1969 (Wolff, 1989). Subsequently, polypectomy was performed with the addition of wire loop snare cautery through an instrument channel. Wolff and Shinya authored the first major report of successful polypectomy in 1973 using early colonoscopes (Wolff, 1989; Wolff and Shinya, 1973). In this report, 218 patients underwent fiberoptic colonoscopy with 313 polyps successfully removed. No deaths were reported, and two of 218 patients had minor blood loss that resolved (Wolff and Shinya, 1973). Colonoscopy has continued to advance with technological advancements in imaging display and engineering. Today, colonoscopes incorporate high-definition imaging and an array of diagnostic and therapeutic tools for polyp sampling and removal through the instrument channel (Wolff, 1989).

In 1976, Winawer et al. described direct visualization screening as a revolutionary CRC screening technique for asymptomatic patients (Winawer et al., 1976). CRC screening using sigmoidoscopy in asymptomatic patients gained recognition in a case-control study by Selby et al. (Selby et al., 1992). This study demonstrated patients who received screening sigmoidoscopy had approximately 30% the risk of death from distal colon and rectal cancers compared to matched patients who did not undergo screening (Selby et al., 1992). Earlier data obtained over 1948–1976 by Gilbertsen and Nelms in the Cancer Detection Study supported direct visualization screening in asymptomatic patients and showed more cancers detected at earlier stages and higher 5-year survival rates in sigmoidoscopy-screened patients (Gilbertsen and Nelms, 1978). Further supporting CRC screening with sigmoidoscopy, the Prostate-Lung-Colorectal-Ovarian Cancer Screening Trial performed throughout the 1990s early 2000s data showed detection of pre-cancerous adenomas in 23% of asymptomatic patients undergoing flexible sigmoidoscopy (Weissfeld et al., 2005).

Colonoscopy as a screening tool in asymptomatic patients was largely introduced in the 1980s by small studies from Love and Morrissey (1984) and followed by Gryska and Cohen (1987). Both studies demonstrated colonoscopy finding adenomas and invasive cancers in asymptomatic patients with first degree relatives diagnosed with CRC (Love and Morrissey, 1984; Gryska and Cohen, 1987). Adding to these, a prospective study by Guillem et al. (1992) with a larger asymptomatic patient population with first degree relatives with CRC demonstrated not only adenomas in 14% of screened patients, but also 48% of these adenomas were beyond the reach of flexible sigmoidoscopy (Guillem et al., 1992). Large cohorts by DiSario et al. and Indiana University throughout the 1990s also strongly supported the use of colonoscopy as a screening tool to the proximal colon in average-risk asymptomatic adults by showing similar results (DiSario et al., 1991; Rex, 1994). With these data, the MSTF made the first landmark guidelines stating colonoscopy should be used for CRC screening in asymptomatic, average-risk patients (Winawer et al., 1997).

In 1993, a landmark study by Winawer et al. first demonstrated the prevention of CRC by removing adenomatous polyps with colonoscopy (Winawer et al., 1993). This study, known as the National Polyp Study, followed a retrospective cohort of 1418 patients over 10 years who underwent colonoscopy with polypectomy. Patients with prior family or personal history of familial polyposis, inflammatory bowel disease, history of polypectomy, or history of CRC were excluded. Furthermore, after initial colonoscopy, patients were then excluded if they had no polyps, non-adenomatous polyps, malignant polyps, a sessile adenoma larger than 3 cm in diameter, or CRC. The cohort included only patients who had at least one histologically documented adenoma of the colon or rectum and had undergone a complete colonoscopy during which all identified polyps were removed. Patients were re-examined with colonoscopy after an average of 5.9 years for development of CRC. Results demonstrated a 90%, 88%, and 76% decrease in CRC incidence compared to matched cohorts from Mayo Clinic, St. Mark's Hospital in London, and SEER registry patients who had completed colonoscopy without polypectomy ($p < 0.001$), respectively. In all, the National Polyp Study provided strong evidence for colonoscopy with polypectomy for preventing CRC (Winawer et al., 1993). In 2000, landmark studies by Lieberman et al. and Imperiale et al. strongly supported screening asymptomatic patients with colonoscopy and showed the impact of colonoscopy on identifying neoplasms. Lieberman et al. screened 3121 asymptomatic veterans through 13 Veteran Affairs medical centers, finding one or more neoplastic lesions in 37.5% of patients and of these, 72% were tubular adenomas $\leq$10 mm (Lieberman et al., 2000). Imperiale et al. screened approximately 2000 asymptomatic patients using colonoscopy and demonstrated proximal colon tubular adenomas in 168 asymptomatic patients and advanced neoplasms in 61 asymptomatic patients (Imperiale et al., 2000). Together, these studies, along with others, solidified colonoscopy as a highly effective CRC screening modality in asymptomatic patients and were endorsed as so by the ACG starting in 2000 (Rex et al., 2000).

3.4. Other screening modalities

Ongoing research today is aimed at developing serum or urine testing for CRC screening in asymptomatic patients. The Septin9 assay (Epigenomics, Seattle, Wash) screens for the presence of free circulating genes with methylated SEPT9, which is present in CRC tissue but not normal colorectal mucosa (Model et al., 2007). Church et al. screened 7941 asymptomatic patients for CRC with this serum assay and obtained a sensitivity of 48% and specificity 91% (Church et al., 2014). However, the sensitivity for adenomas was very poor (11.2%), and its cost is high in an age of cost-effective medicine, which has limited its recommended screening use by the MSTF and ACG as of 2017 (Rex et al., 2017; Church et al., 2014). Currently, the Septin9 assay is cleared for colorectal neoplasia detection by the United States Food and Drug Administration (FDA), but is largely limited to patients with histories of non-adherence to other forms of CRC screening. Spot-urine tests are currently being studied as a means of screening asymptomatic patients. These urine tests screen for metabolites that are produced by microbiomes, termed “metabolomics”, commonly seen in adenomatous mucosa and CRC (Wang et al., 2010a, 2010b). Data has demonstrated sensitivities reaching 82% with these urine assays (Wang et al., 2014). More research is needed at this time to improve the detection of precancerous lesions and cost-effectiveness of these tests.

Additionally, capsule endoscopy has been utilized for CRC screening as a third-tier modality. Capsule endoscopy benefits mostly patients with anatomic irregularities resulting in failed colonoscopies, intolerance of sedation, or preference for less invasive screening. However, this modality has several pitfalls: inability to intervene on lesions immediately, extensive bowel preparation, time-intensive result interpretation, and reliance on capsule camera position for polyp identification. Screening results using capsule endoscopy have varied but recent data in average-risk patients report > 6 mm adenoma detection sensitivities of 84–89% and specificities of 64–76% (Spada et al., 2011; Red et al., 2015). The FDA approved capsule endoscopy use for lumenal imaging, however it has yet to be endorsed for CRC screening purposes (United States Food and Drug Administration, n.d.-b). Together, these alternative CRC screening modalities have yet to be strongly recommended by national medical associations or included in widely used national quality performance measures.

4. Quality measures for colorectal cancer screening

Over the last two decades, attention has been directed towards the quality of endoscopic CRC screening. Different quality measures have been introduced such as cecal intubation rate, withdrawal time, split-dose prep, and adenoma detection rate (ADR) (Rex et al., 2002; Barclay et al., 2006; Kaminski et al., 2010). These quality metrics have been developed with the intent of providing patients with high-quality CRC screening as well as providing gastroenterologists insight to individual CRC screening performance (Rex et al., 2017). Of the quality measures, ADR has surfaced as the premier metric for assessing screening quality, with other quality metrics aimed at improving ADR (Rex et al., 2017). ADR is defined as the percentage of patients aged ≥50 year-old undergoing first-time screening who have one or more adenomas detected and removed (Rex, n.d.). Landmark studies by Kaminski et al. (2010), Corley et al. (2014), and Kaminski et al. (2017) have demonstrated increased screening ADR is strongly associated with reduced risk of CRC and death. Current MSTF recommendations and updated ACG 2017 guidelines promote ADRs of ≥25% for patients overall with ≥30% in men and ≥20% in women (Rex et al., 2017). Regarding the other quality metrics, cecal intubation rates—defined as the percentage of screening colonoscopies visualizing the cecal mucosa—of ≥95% are recommended for ensuring quality screening (Rex et al., 2017). Additionally, 6 to 10-minute withdrawal times from cecum to anus are recommended. This recommendation was supported by Barclay et al. in 2006 that demonstrated screening colonoscopy withdrawal times ranging from 6 to 10 min resulted in significantly increased small (1 cm) adenoma detection rates compared to < 6 min (Barclay et al., 2006). Likewise, the use of a "split-dosed prep" has been adopted as a quality measure to improve screening colonoscopy. A 2012 study of 1615 patients by Gurudu et al. demonstrated a 5% increase in ADR with patients drinking at least half of the required colonic preparation on day of screening exam compared to traditional practice. This study also demonstrated increased percentages of successful screening completion and better visualization of colonic mucosa compared to traditional colonic preparation (Gurudu et al., 2012). As a whole, these quality metrics have developed a check on CRC screening colonoscopy and are providing practitioners with insight to individual screening efficacy.

Quality measures have been introduced by the MSTF for optimizing FIT CRC screening as well. FIT quality measures focus on meeting goals of completion of screening, sample success, and colonoscopy follow up rates. Current recommendations are to obtain ≥60% completion rate of FIT to offered patients and ≥95% of FIT samples processed correctly. Additionally, ≥80% of positive FIT screened patients should receive colonoscopy to ensure quality FIT CRC screening (Robertson et al., 2017). The quality metrics of FIT screening need further study in order to validate these recommendations.

5. Healthcare legislation improving access to colorectal cancer screening

The passage of the Patient Protection and Affordable Care Act (PPACA) by the Obama Administration instituted coverage of screening colonoscopy without copayments to improve coverage of preventative medicine (H.R. 3590, 2009). However, this legislation initially classified screening colonoscopy as "diagnostic" or "therapeutic" instead of "preventative" if polypectomy or biopsy were performed. Colonoscopy coded as diagnostic or therapeutic was not covered in full and resulted in additional costs for patients. This coding policy has been similar to previous private insurer, Medicare, and Medicaid policies as well. For example, one private insurer policy states if a screening colonoscopy discovers polyps, all follow-up exams, for instance in 5 years, would be labeled as diagnostic instead of screening due to "time intervals between future colonoscopies [being] shortened" (*United HealthCare Commercial*, n.d.). Similar to Medicare coding policies, these future exams would result in more cost-sharing for patients. Importantly, in 2012, PPACA policy was updated to cover polypectomy during screening colonoscopy, however Medicare beneficiaries were not included in the updated law. Medicare beneficiaries are currently required to pay 20% of charges if polypectomy is performed during a screening colonoscopy (Madry, 2013). Despite financial burdens, expansion of CRC screening coverage mandates on federal and state-level over the last two decades has resulted in significant improved CRC screening rates nation-wide (Harewood and Lieberman, 2004).

In April 2015, U.S. Senator Ben Cardin and Representative Richard Neal introduced the Supporting Colorectal Examination and Education Now (SCREEN) Act of 2015, or H.R. 2035 (SCREEN Act of 2015, 2015). The SCREEN Act aims to improve coverage for CRC and hepatitis C screening under Medicare and private insurance. This bill proposed to eliminate Medicare beneficiary cost-sharing for CRC screening involving tissue removal, which decreases financial burdens of Medicare patients. Also, the bill would allow Medicare recipients coverage for an out-patient visit prior to screening colonoscopy to review pre-procedure preparation, answer patient questions, and schedule hepatitis C screening at the same visit (SCREEN Act of 2015, 2015). Proponents of this bill often cite Sears et al. that demonstrated improvement in hepatitis C screening rates when patients were offered hepatitis C screening when scheduling screening colonoscopy (Sears et al., 2013). Additionally, the bill amends titles XI and XVIII of the Social Security Act to maintain 2015 Medicare reimbursement rates for colonoscopy for providers participating in a CRC screening quality improvement registry, thus incentivizing providers with higher reimbursement if screening colonoscopy rates meet national screening goals (SCREEN Act of 2015, 2015).

In May 2015, the United States Congress referred the SCREEN Act for review in the Subcommittee on Health. The SCREEN Act remained under review until the 114th Congress term ended in January 2017. Further progress of the SCREEN Act will be determined by future congressional terms. Similar legislation has been introduced by U.S. Representative Charles Dent and Senator Sherrod Brown in March 2015. The Removing Barriers to Colorectal Cancer Screening Act of 2015 aims to amend the Social Security Act to include coverage for tissue removal or other procedures during a screening colonoscopy (Removing Barriers to Colorectal Screening Act of 2015, 2015a; Removing Barriers to Colorectal Screening Act of 2015, 2015b). Similarly, this bill remained in the Subcommittee on Health and Committee of Finance at the time the 114th Congress term ended.

6. Where we are going: 80% by 2018

In 2014, the National Colorectal Cancer Roundtable (NCCRT), sponsored by the ACS, launched a campaign to increase CRC screening rates (National Colorectal Cancer Roundtable, n.d.). NCCRT proposed a goal of increasing CRC screening rates to 80% by the year 2018 from the 2014 rate of 65.7% (Wender, 2016). The United States Centers for Disease Control and a study by Meester et al. support the potential impact of achieving an 80% CRC screening rates (Centers for Disease Control and Prevention (CDC), 2014; Meester et al., 2015). Meester et al. reports if 80% screening rates are obtained, 277,000 cases of CRC could be diagnosed, and 203,000 CRC deaths would be prevented (Meester et al., 2015). Four areas of potential intervention have been identified and are being addressed to achieve this goal: consumers, systems, policy, and process. Strategies to move consumers to action include improving outreach to low socio-economic populations and educating the newly insured. The 2016 NCCRT Mid-Way Update discussed consumer-focused initiatives such as integrating CRC survivors' stories, providing native language guidebooks for English and non-English speaking patients and providers, and increasing outreach through social media and television. Systems-based strategies have aimed to use providers, payers, and employers to support screening. Overall objectives include more effective engagement from healthcare providers and payers, connecting healthcare providers around Federally

Qualified Health Centers, integrating comprehensive cancer control programs and coalitions, and ensuring all patients have access to stool-based blood tests. Additionally, the 2016 NCCRT Mid-Way Update discussed policy implementation at a local, state, and national level to make CRC screening more affordable and accessible. On-going initiatives include efforts to waive cost-sharing for colonoscopy and inform governors and mayors of screening goals. Process goals center on maintaining momentum by recruiting more partners. The NCCRT recognizes several barriers to CRC screening that have prevented achievement of 80% national CRC screening rates. These barriers include factors such as lack of affordability, negative connotation with screening modalities, and no symptoms. Interestingly, one top barrier to CRC screening identified is rationalized avoidance. This barrier describes a patient whom is knowledgeable and has financial means for screening, but fails to recognize its importance. ACG interventions have started to address rationalized avoidance and include utilizing social media and traditional media outlets to stress the importance of CRC screening. To date, over 1000 pledges have been signed by healthcare providers to achieve 80% screening rates by 2018 (Wender, 2016).

7. Conclusion

Great strides have been made in the early detection and prevention of CRC, with a major victory in 1997 with passage of the Balanced Budget Act, for the first time providing Medicare coverage for CRC screening. Looking back over the past 20 years, the incidence and mortality rates of CRC have fallen. Racial and socioeconomic disparities still exist in screening, and efforts are underway to address and overcome barriers to access. New legislation and initiative efforts are on-going and aim to improve colorectal screening rates in the hopes of achieving colorectal screening in 80% of eligible patients by 2018.

Author contributions

Eric M. Montminy, MD
-Conducted literature review and was primary author of manuscript.
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-Participated in writing and editing manuscript. Was overseeing author for the submission.

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